Write your name, centre number and candidate number in the boxes below.

Surname	Other names

Centre number | | | | | |

Candidate number | | | | |

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Experimental design and separation techniques

Time allowed: 1 hour 35 minutes

Subject code **0620**

Chemistry

Questions from Paper 3, Paper 4 and Paper 6

You must have: a ruler marked in centimetres and millimetres, a protractor, compasses, a pen, an HB pencil and an eraser.

Total marks

/ 76

Instructions

- Answer every question in the space provided on this paper.
- Write in black or dark blue ink. Pencil may be used for diagrams and graphs.
- Fill in your name, centre number and candidate number above.
- Show your working: a correct method can earn marks even if the answer is wrong.

Information

- This paper has 10 questions worth 76 marks in total.
- The marks for each question or part are shown in brackets, for example [3].

Advice

- Read every question through once before you write anything.
- Use the marks in brackets to judge how long to spend on each part.
- If you finish early, go back and check your working.

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Print at 100% (Actual size) so diagrams keep their real measurements.

1 Give the name of the process that is used:

(a) to obtain water from aqueous sodium chloride

..... [1]

(b) to produce lead from molten lead(II) bromide

..... [1]

(c) to separate an insoluble solid from a liquid

..... [1]

(d) to separate the components of petroleum

..... [1]

(e) to separate a mixture of coloured dyes.

..... [1]

[Total: 5]

Separation and purification Click for more variations

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1(a)	distillation	**1**
1(b)	electrolysis	**1**
1(c)	filtration	**1**
1(d)	fractional distillation / fractionation	**1**
1(e)	chromatography	**1**

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2 Chromatography can be used to test for the purity of substances.

(a) (i) Describe **one** area in everyday life where purity of substances is important.

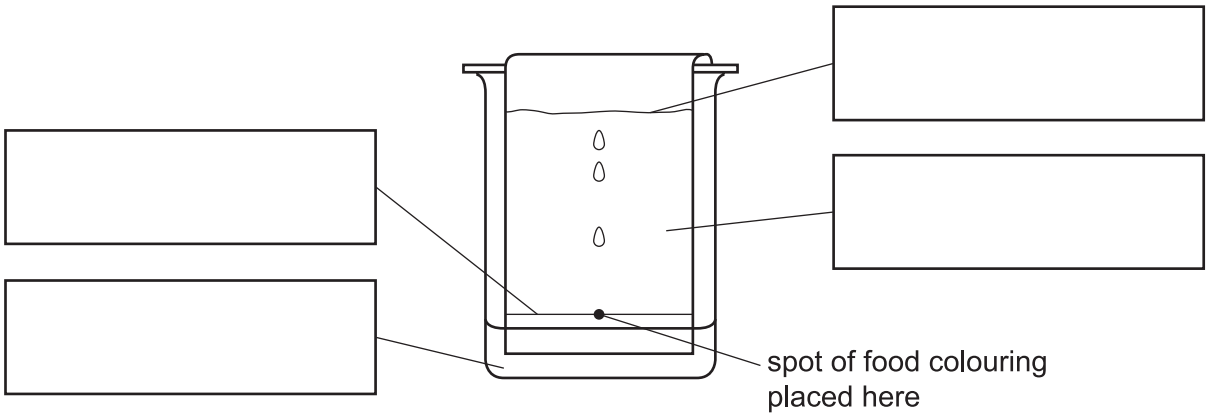
..... [1]

(ii) Mineral water contains dissolved salts such as magnesium chloride.
Which one of the following statements about mineral water is correct?
Tick **one** box.

Mineral water boils at slightly above 100 °C.	☐
Mineral water is pure water.	☐
Mineral water boils at exactly 100 °C.	☐
Another name for mineral water is fizzy water.	☐

[1]

(b) The diagram shows the apparatus used to separate different dyes in food colourings.

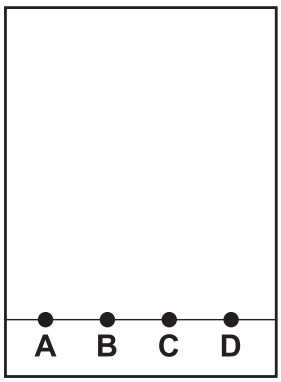


Label the diagram in the boxes provided using the words below.

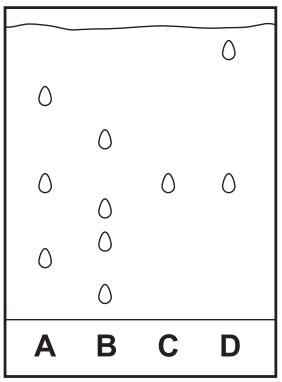
chromatography paper **origin line** **solvent** **solvent front** [2]

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(c) The diagram below shows the chromatography of four different food colourings, **A**, **B**, **C** and **D**.



at the start of the experiment



the final chromatogram

(i) Which food colouring, **A**, **B**, **C** or **D**, contains only one dye? ..... [1]

(ii) Which **three** food colourings have one dye in common? ..... [1]

(iii) Which food colouring contains the greatest number of dyes? ..... [1]

[Total: 7]

Chromatography Click for more variations

2 **(a)** **(i)** medicines / food / (drinking) water / air quality [1]
ignore: kitchens / clothes

(ii) 1st box down ticked (boils slightly above 100 °C) [1]

(b) all 4 correct = 2 marks [2]
2 or 3 correct = 1 mark
0 or 1 correct = 0 marks
top right → solvent front
bottom right → chromatography paperbottom left → solvent
top left → origin line

(c) **(i)** C [1]

(ii) A, C and D (all three correct for 1 mark) [1]

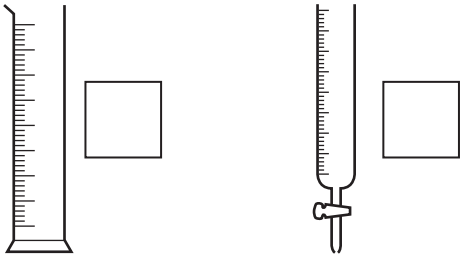
(iii) B [1]

[Total: 7]

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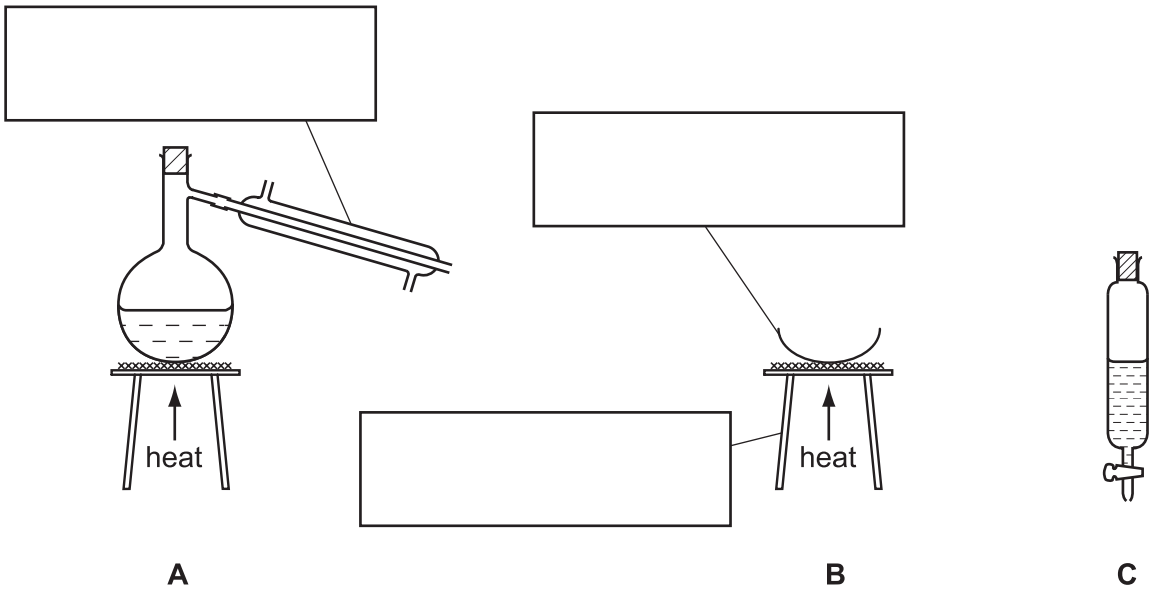
3 A student separated an aqueous solution of sodium chloride.
She measured out 70 cm^3 of the solution and then obtained pure water from the solution.

(a) Which of these pieces of apparatus is most suitable to measure 70 cm^3 of the solution?
Tick **one** box.



[1]

(b) **(i)** Complete the empty boxes to name the pieces of apparatus below.



A **B** **C**

[3]

(ii) Which method of separation, **A**, **B** or **C**, would be most suitable to obtain pure water from the solution?

apparatus ..... [1]

(c) Describe how crystals of sodium chloride could be quickly obtained from the solution.

.....

.....

..... [2]

[Total: 7]

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Practical skills: planning, apparatus, measuring and results Click for more variations

3 **(a)** measuring cylinder (1) [1]

(b) **(i)** condenser (1) **accept** condensing tube
evaporating dish/basin/bowl (1) accept crystallising dish/basin/bowl
tripod (1) [3]

(ii) A/distillation (1) [1]

(c) **ignore** reference to filtering
heat/evaporate/use apparatus B (1) **not** 'heat' if the method would not work
to crystallising point/until saturated (1) [2]

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4 When a mixture of calcium hydroxide and ammonium chloride is heated, ammonia gas is made.

calcium hydroxide + ammonium chloride → calcium chloride + water + ammonia

Ammonia gas is soluble in water and toxic. Ammonia gas reacts with hot copper(II) oxide to make nitrogen.

ammonia + copper(II) oxide → copper + water + nitrogen

A student makes nitrogen using the apparatus shown in Fig. 1.1.

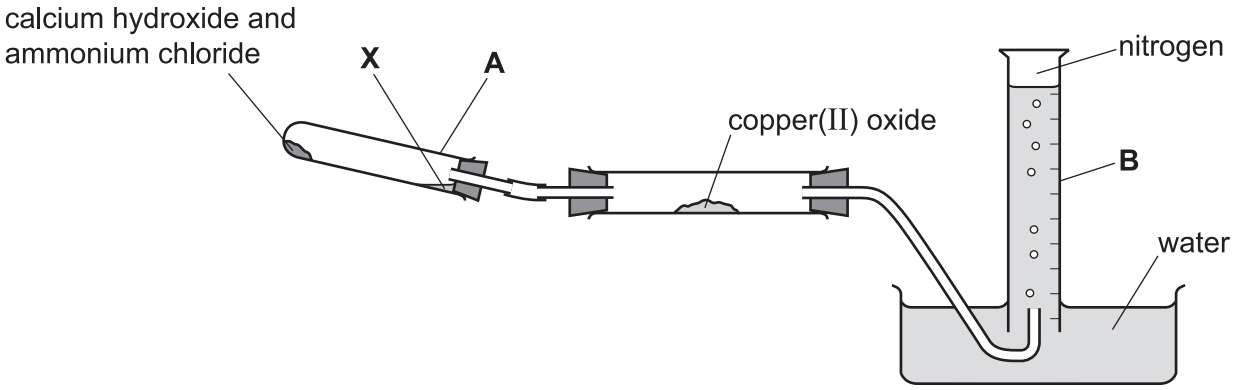


Fig. 1.1

(a) Name the items of apparatus labelled **A** and **B** in Fig. 1.1.

A .....

B .....
[2]

(b) The apparatus needs to be heated in two places.

On Fig. 1.1, draw arrows in **two** places to show where the apparatus should be heated during the experiment. [2]

(c) During the reaction, a colourless liquid collects at the point marked **X** in Fig. 1.1.

Suggest the identity of the colourless liquid.

..... [1]

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(d) Some of the ammonia gas passes over the copper(II) oxide without reacting.

Suggest why none of this ammonia gas is collected in the item of apparatus labelled **B** in Fig. 1.1.

.....

..... [1]

(e) The student does not collect the first few bubbles of gas.

Suggest why the first few bubbles of gas are **not** collected.

.....

..... [1]

(f) Explain why this experiment should be carried out in a fume cupboard.

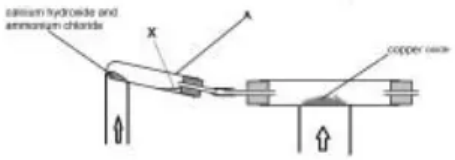
.....

..... [1]

[Total: 8]

Practical skills: planning, apparatus, measuring and results Click for more variations

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4(a)	**A** boiling tube / test-tube	1
	B measuring cylinder	1
4(b)	 one arrow in each region shown	2
4(c)	water / H_2O	1
4(d)	ammonia dissolves in the water	1
4(e)	it is air	1
4(f)	ammonia is toxic / poisonous	1

STEM

5 A black dye can be obtained from some plant roots.

Plan an investigation to determine how many different coloured substances are contained in a black dye obtained from plant roots.

You must include how the results you obtain will tell you how many different coloured substances are contained in the black dye.

You have access to plant roots and all normal laboratory apparatus.

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..... [6]

Practical skills: planning, apparatus, measuring and results Click for more variations

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5	Any 6 from: • crush / grind root • with pestle / mortar • with water / solvent • place (drop of) liquid / colour on paper • conduct chromatography • (bottom of) paper placed in a suitable solvent / water • number of coloured substances = number of spots	**6**

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6 Cobalt, manganese and nickel are metals. They react with dilute hydrochloric acid to form hydrogen gas.

Plan an investigation to find the order of reactivity of these three metals.

You are provided with:
- samples of each metal
- dilute hydrochloric acid
- common laboratory apparatus.

Your plan must make it clear how your investigation will be a fair test and how you will use your results to place the metals in order of reactivity.

.....

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..... [6]

Practical skills: planning, apparatus, measuring and results Click for more variations

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6	add metals to HC*l* in a beaker / flask / test-tube **fair test – max 4** • same volume HC*l* • some concentration HC*l* • same temperature acid • same mass / moles / amount metals • same surface area / form of metal **measure** • start timing when solid added • stop timing when all solid gone / reaction to stop	**6**

6	**OR** • start timing when solid added • stop timing when collected set volume of gas **OR** • start timing when solid added • measure volume of gas after a set time **OR** • measure temperature at start • measure temperature after reaction **OR** highest temperature reached **conclusion** • shortest time is most reactive **OR** • biggest volume of gas most reactive **OR** • biggest temperature change most reactive	

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7 A **mixture** contains three compounds:

- liquid ethanol
- solid sodium chloride
- solid zinc carbonate.

Table 4.1 gives some information about these three compounds.

Table 4.1

name of compound	solubility in water	solubility in ethanol
ethanol	soluble	
sodium chloride	soluble	insoluble
zinc carbonate	insoluble	insoluble

Describe how to obtain a pure sample of each of the three compounds, ethanol, sodium chloride and zinc carbonate, from the mixture.

You are provided with common laboratory apparatus.

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..... [6]

Separation and purification Click for more variations

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7	**max 6** **to obtain ethanol** **MP1** filter the initial mixture (ethanol obtained as filtrate)	**1**
	and then any five from: **to obtain zinc carbonate** **MP2** add water to the residue / mixture **MP3** stir / warm after adding water **MP4** filter after adding water **MP5** wash residue from filtration after the addition of water **MP6** dry the solid zinc carbonate **to obtain sodium chloride** **MP7** heat filtrate to remove water and obtain solid sodium chloride **If candidates do not have a valid method of obtaining ethanol then MP1 cannot be awarded and the maximum score is 5. If ethanol is obtained AFTER adding more ethanol to the mixture, then do not award MP1, maximum 5**	**5**

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8 Magnesium sulfate is a salt. Magnesium sulfate is soluble in water.

The solubility of a salt is the mass of the salt, in g, that dissolves in 100 cm^3 of water at a specified temperature.

Plan an investigation to determine the solubility of magnesium sulfate in water at 50 °C. Your plan must include how the solubility of magnesium sulfate, in g per 100 cm^3 of water, can be found.

You are provided with solid magnesium sulfate, distilled water and common laboratory apparatus.

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Practical skills: planning, apparatus, measuring and results Click for more variations

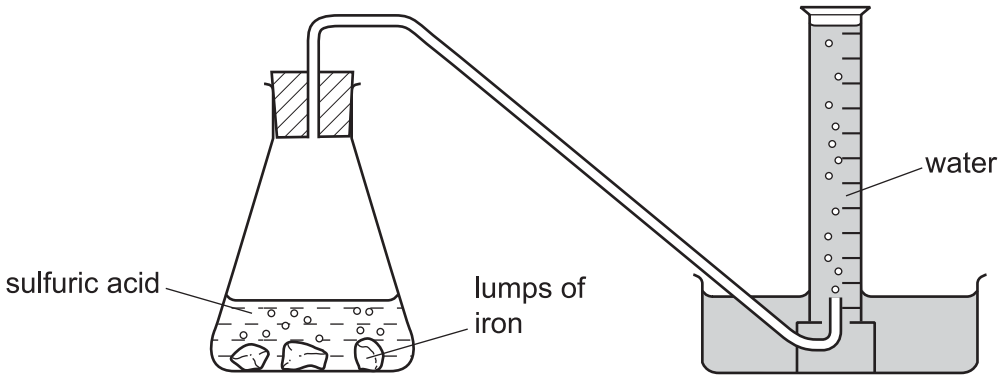
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8	**1 mark for any 6 of:** • 100 cm^3 of water measured using suitable apparatus and placed into a suitable container • water is heated to 50 °C • water is maintained at this temperature • magnesium sulfate is added in excess or in portions until no more dissolves • the mixture is stirred • the solution is filtered to remove undissolved magnesium sulfate or the mass used is known • the use of appropriate measurements to calculate the solubility.	6

9 A student investigated the reaction of lumps of iron with sulfuric acid.

$$Fe(s) + H_2SO_4(aq) \rightarrow FeSO_4(aq) + H_2(g)$$

She used the apparatus shown below.



(a) (i) Describe how this apparatus can be used to investigate the rate of this reaction.

.....

.....

..... [3]

(ii) Describe how the rate of reaction would differ if smaller lumps of iron were used. All other conditions remain the same.

..... [1]

(b) The student investigated the effect of temperature on the reaction rate.

(i) State **three** factors which the student should keep the same in each experiment.

1. .....

2. .....

3. .....

[3]

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(ii) The table shows how the rate of reaction changed with temperature.

temperature /°C	rate of reaction in cm^3/s
20	2.2
30	4.4
40	8.8
50	17.6

Use the information in the table to describe how the rate of reaction changed with temperature.

.....

..... [2]

(c) Iron(II) sulfate can be prepared by adding excess iron to sulfuric acid.

Describe how you could obtain pure dry crystals of iron(II) sulfate from the reaction mixture in the conical flask.

.....

.....

.....

..... [3]

[Total: 12]

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Rates of reaction Click for more variations

9(a)(i)	measure volume of gas / measure amount of gas; gas collected in the measuring cylinder; at different times / use of stopclock to measure time;	**1** **1** **1**
9(a)(ii)	faster reaction / rate increases;	**1**
9(b)(i)	same concentration of acid; same mass of iron; same size of iron pieces;	**1** **1** **1**

9(b)(ii)	rate increases with increase in temperature rate increases with temperature = [1]	**2**
9(c)	any three from: • filter (off the iron); • evaporate water / heat gently; • to crystallisation point / leave to cool (after heating); • filter off / pick out crystals; • dry crystal between filter papers;	**3**

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10 Substances can be classified as elements, compounds or mixtures.

(a) What is meant by the term *compound*?

.....

.....

..... [2]

(b) Mixtures can be separated by physical processes.

A sequence of physical processes can be used to separate common salt (sodium chloride) from a mixture containing sand and common salt only.

Give the order and the correct scientific term for the physical processes used to separate the common salt from the mixture.

1 .....

2 .....

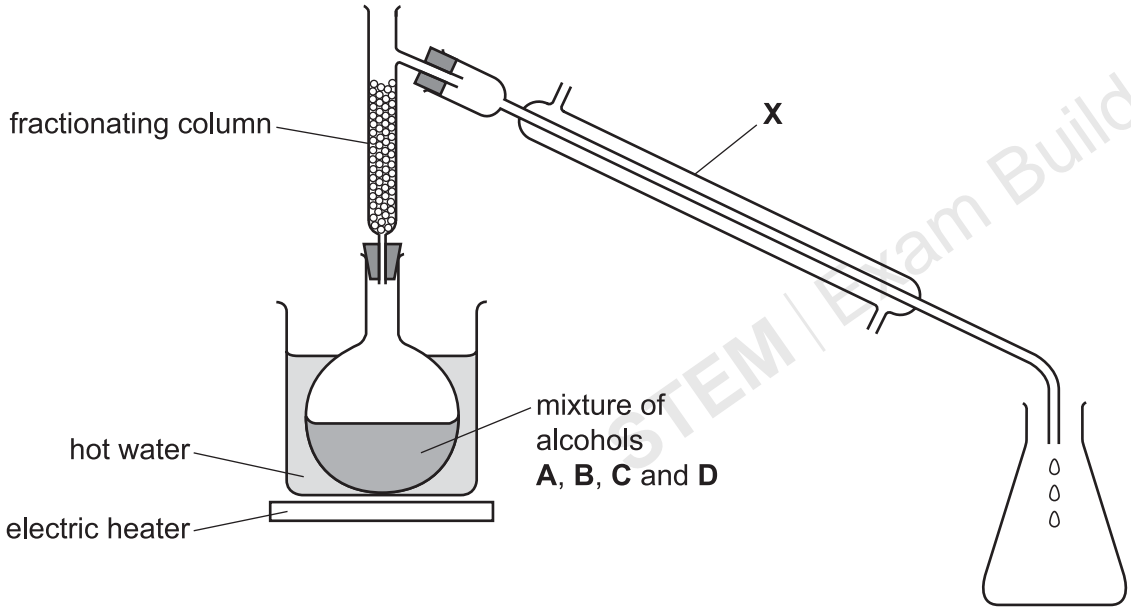
3 .....

[4]

The boiling points of four different alcohols, **A**, **B**, **C** and **D**, are shown.

alcohol	**A**	**B**	**C**	**D**
boiling point / °C	56	78	122	160

(c) A student suggested that the apparatus shown could be used to separate the mixture of alcohols.



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(i) Apparatus **X** needs to have cold water flowing through it.

- Draw an arrow on the diagram to show where the cold water enters apparatus **X**.
- Name apparatus **X**.

.....

[2]

(ii) Part of the fractionating column is missing. This means that the experiment will not work.

- Draw on the diagram the part of the fractionating column which is missing.
- Explain why the experiment will **not** work with this part of the fractionating column missing.

.....

.....

[2]

(iii) Suggest why a Bunsen burner is **not** used to heat the flask.

..... [1]

(iv) A hot water bath cannot be used to separate alcohols **C** and **D**.

Explain why.

.....

.....

..... [2]

[Total: 13]

Separation and purification Click for more variations

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10(a)	a substance made from two (or more) **elements**	**1**
	chemically combined	**1**
10(b)	dissolving	**1**
	filtration	**1**
	evaporation / crystallisation	**1**
	three correct stages in the correct order	**1**
10(c)(i)	condenser	**1**
	arrow pointing into lower aperture **only**	**1**
10(c)(ii)	stopper shown in diagram	**1**
	gases or vapours escape	**1**
10(c)(iii)	(mixture is) (in)flammable	**1**
10(c)(iv)	water bath cannot exceed 100 (°C)	**1**
	C AND D have a boiling point above 100 (°C)	**1**

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